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work the two electro-magnets well. A separate battery of about the same size is used for the hammer and fillet magnets.

In point of accuracy this machine leaves nothing to be desired, and is much beyond what we thought possible. From a vast number of experiments, made by recording automatically the beats of the standard clock, both at the middle and end of the oscillation, the mean error for a single print is found to be $0^s{\cdot}013$, equal in this respect to the recording chronograph. The maximum difference in the records of the beats seldom exceeds $0^s{\cdot}03$, and we believe this is as much due to the irregularity in the clock connexion, as in the running of the machine, since the same thing is found in ordinary chronographic records, where the measures are made from second to second.

The saving of time and labour by the use of a printing chronograph is very considerable. At the lowest estimate it does work equivalent to the labour of one person where three are employed at the same time. In our zone-work in former years, when the zone extended two hours in right ascension, it usually required the labour of two persons a whole day to convert the chronograph records into numbers and copy them on the blank forms. With the observations printed this labour is wholly dispensed with, since the "mean" is at once deduced from the printed records.

The machine is readily adjusted to indicate the same numbers as the clock's face, the type being so set as to print zero-hundredths when the pendulum is at its lowest point, where the magnetic circuit is completed.

In the observation of zone-stars or regular transit-work the type may be set to give the integer seconds of mean right ascension, so that the final reduction will always be a small quantity.

The constant use of this mechanism on every day and observing for six months, during which time more than twelve thousand records have been made, enables us to speak with confidence of its success, both as regards correctness in printing and in saving of labour.

Other things being equal it is found that for three observers twice as many observations can be reduced in the same time as when a recording chronograph is employed.

Formulæ for the Calculation of the Orbit of a Double Star.

By M. Annibal de Gasparis. (Translation.)

Having reduced by Herschel's method (*Memoirs R.A.S.* vol. v.) positions for six equidistant epochs, let $\varrho_1, \varrho_2 \ldots \varrho_6$ be the distances and $\phi_1, \phi_2 \ldots \phi_6$ the angles of position. Denoting by m_{rs} the triangular area described on the plane of projection, and com-

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prised between the distances ϱ_r and ϱ_s, we have $m_{rs} = \frac{1}{2} \varrho_r \varrho_s \times \sin(\phi_r - \phi_s)$. This being so, developing the area m_{rs} described on the plane of the orbit as a function of the radius vector and its derivatives, including the terms multiplied by the sixth powers of the times, we have to determine the ratios of the radius vectors r_2, r_3, r_4 the two equations,—

$$\frac{r_2^3}{r_3^3} = \frac{42\,m_{23} - 50\,m_{34} - 6\,m_{45} - 18\,m_{24} + 13\,m_{35} - 11\,m_{46} + 40\,m_{56} + 2\,m_{25}}{42\,m_{12} - 50\,m_{23} - 6\,m_{34} - 18\,m_{13} + 13\,m_{24} - 11\,m_{35} + 40\,m_{45} + 2\,m_{14}},$$

$$\frac{r_3^3}{r_4^3} = \frac{42\,m_{45} - 50\,m_{34} - 6\,m_{23} - 18\,m_{35} + 13\,m_{24} - 11\,m_{13} + 40\,m_{12} + 2\,m_{25}}{42\,m_{23} - 50\,m_{34} - 6\,m_{45} - 18\,m_{24} + 13\,m_{35} - 11\,m_{46} + 40\,m_{56} + 2\,m_{25}}.$$

These ratios being known, the direct calculation of the elements is quickly effected, since in fact the numerators and denominators are quantities of the third order. For this reason I thought it proper to use six positions (instead of four, which would have been sufficient) to attenuate in Herschel's curve the errors of observation, making use of a larger number of data. The memoir containing the necessary developments and other details will appear in vol. vi. of the *Atti* of the Academy of Sciences of Naples.

Occultation of Vesta, Dec. 30, 1871. By C. G. Talmage, Esq.

The occultation of *Vesta* was well seen here on the 30th Dec. The day had been very wet, but by 9·30 P.M. the sky was quite clear. *Vesta* was exceedingly bright right up to the Moon's limb.

The G.M.T. of immersion was

$10^h\ 44^m\ 24^s{\cdot}8$

and of emersion

$11^h\ 52^m\ 52^s{\cdot}6.$

Both exact. Power 80 on 10-inch refractor.

Note on the Variable Star S *Orionis.* By the Rev. T. W. Webb.

I have taken the earliest opportunity of reobserving the little variable star S *Orionis*, the character of whose light, suspected early in the year 1870, I was so fortunate to ascertain satisfactorily about this time twelve months ago. I find that it is now considerably smaller than on any previous occasion when I have looked for it; and as it is well situated among comparison-stars,

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